Russian Wheat Aphid

A Progress Report to the National Association of State Departments of Agriculture

March 1, 1991

Table of Contents

February 20, 1991

Dr. J. B. Grant
Executive Secretary, National Association
of State Departments of Agriculture
1616 H. Street, NW
Washington, DC 20006

Dear Dr. Grant:

The National Russian Wheat Aphid Steering Committee has continued to actively participate in the coordination of research and educational programs related to the control of Russian wheat aphid. We welcome the National Barley Growers Association as a member of the committee and appreciate the support and encouragement from a number of cereal associations, councils, boards and commissions.

The 1991 Russian Wheat Aphid Report to the National Association of State Departments of Agriculture reflects the coordinated program results generated through the Western Research Coordinating Committee, WRCC-66, "Biology and Control of Russian Wheat Aphid." Scientists and specialists from State Agricultural Experiment Stations, USDA-ARS, USDA-APHIS, USDA-CSRS and the Cooperative Extension System represent the membership of WRCC-66 and collaborated on specific programs. Individual agency reports are available which detail specific projects and results.

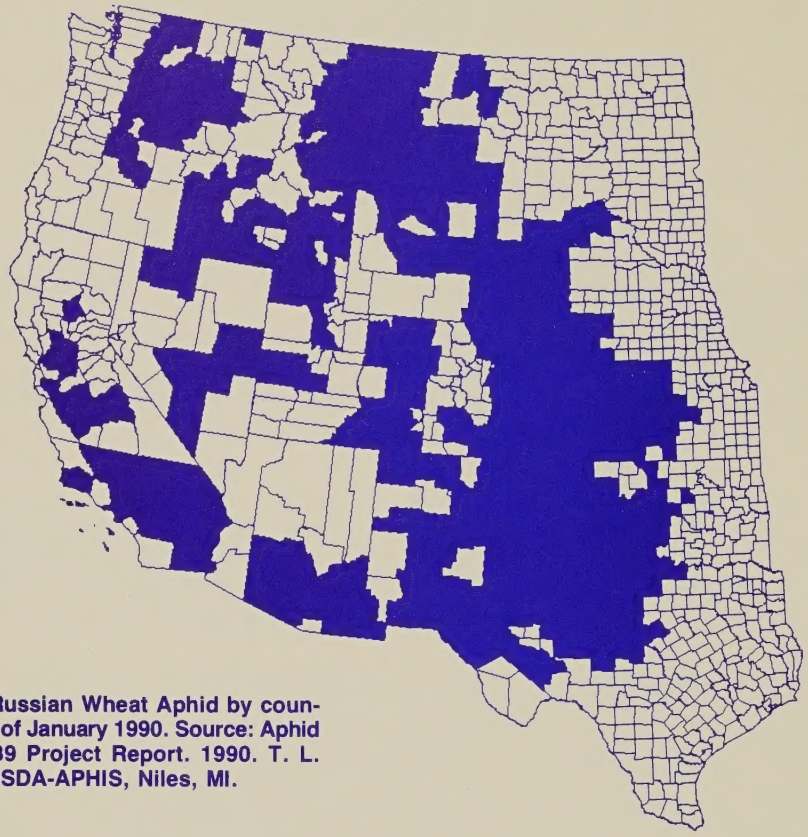
Although excellent progress is being made to develop and implement control measures for Russian wheat aphid, much work still needs to be done as soon as possible. Aphid infestations continue to cause serious economic loss to wheat and barley crops in many growing areas. Yield and quality losses have created economic hardship for growers throughout the western United States. Need to apply pesticides to protect cereal crops has increased production costs at a time of declining prices, drought conditions and tight financial policies. The added financial burden of controlling this pest has caused serious economic problems for numerous growers.

The U.S. Congress appropriated $2.95 million in FY91. Some of the funding was redirected within agencies, taking away funds from other important agricultural programs. States have redirected funding and grower associations have provided resources to address the Russian wheat aphid problems. Thus, it is imperative that the FY92 federal budget provide funding at an appropriate level to help solve this national problem.

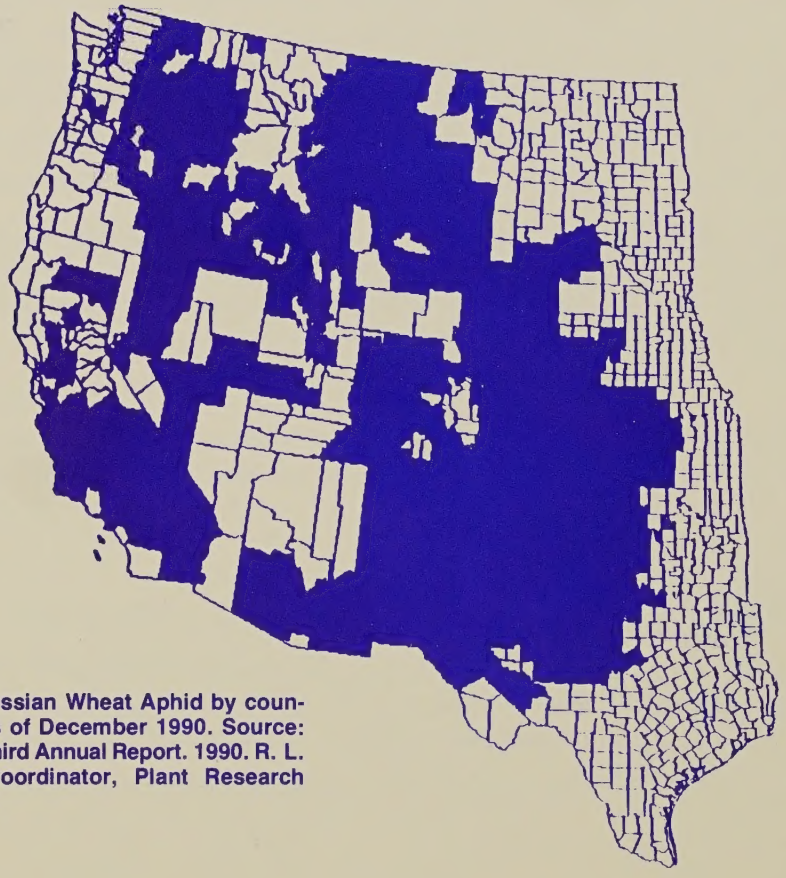
On behalf of the National Russian Wheat Aphid Steering Committee, I want to thank you and NASDA for continued support and encouragement. We are pleased to provide the 1991 Russian Wheat Aphid Report.

Gary A. Lee, Chairman
National Russian Wheat Aphid
Steering Committee

Russian Wheat Aphid Distribution



Reported distribution of Russian Wheat Aphid by counties in the United States as of January 1990. Source: Aphid Biological Control FY 1989 Project Report. 1990. T. L. Burger, Project Leader, USDA-APHIS, Niles, MI.



Reported distribution of Russian Wheat Aphid by counties in the United States as of December 1990. Source: The Russian Wheat Aphid Third Annual Report. 1990. R. L. Burton, ARS Technical Coordinator, Plant Research Laboratory, Stillwater, OK.

National Russian Wheat Aphid Integrated Pest Management Program

Executive Summary

The national coordinated program to develop effective control of the Russian wheat aphid (RWA) has been in existence for three years. Significant research contributions have provided an understanding of the aphid's life cycle, adaptability, distribution and economic damage to cereal crops. In addition, educational materials and programs are being delivered to producers so that this knowledge can be incorporated into management practices at the farm level. Despite the orchestrated efforts of research scientists, extension specialists and regulatory personnel, the pest continues to cause severe crop yield losses and product quality reduction throughout the western United States. In addition, infestations of the aphid continue to spread to previously uninfested areas resulting in increased use of pesticides and crop loss.

The state agricultural experiment stations, United States Department of Agriculture (USDA) including Agricultural Research Service (ARS), Animal and Plant Health Inspection Service (APHIS), Cooperative State Research Service (CSRS) and Cooperative Extension System (CES); state departments of agriculture; National Association of Wheat Growers; National Barley Growers Association; National Agricultural Chemical Association; and the National Plant Board are actively coordinating programs and projects to direct funding into highest priority areas and ensure unnecessary duplication is avoided. The National Russian Wheat Aphid Integrated Pest Management Program has been endorsed by a number of national, regional and state councils, committees and grower organizations. The devastating crop loss that has been experienced throughout wide geographic areas has stimulated strong support for this program from the cereal industry. A number of groups have initiated action to address the Russian wheat aphid problem which further justifies the need for careful coordination of efforts to maintain effective progress.

The United States Congress appropriated and directed $2.95 million to support research on Russian wheat aphid in fiscal year 1991. While these funds provide some assistance, less that one-third of the needed resources are being provided to address an acute national problem. Federal appropriations to USDA-ARS were reduced to $550,000 and USDA-APHIS was directed to reallocate $1.4 million from existing programs. In addition, the funds for USDA-CSRS were directed to four states leaving 10 states with active research programs without opportunity for additional assistance. The National Russian Wheat Aphid Steering Committee has developed a long-range plan which requires $9.5 million of federal assistance in addition to the redirected resources presently being provided.

The 1991 Progress Report contains the contributions of scientists and specialists participating in the Western Regional Research Committee, WRCC-66, "The Biology and Control of Russian Wheat Aphid." The collective contributions of scientists working together, regardless of agency, is indeed impressive. State and federal researchers are jointly addressing components of the six project objectives. This report does not attempt to separate contributions, but rather, show the benefits derived from collaborative research. Individual annual reports to the National Association of State Departments of Agriculture have been prepared by agencies which complement this report. The Great Plains Agricultural Council[1] has published a report on the economic impact of Russian wheat aphid. USDA-ARS and USDA-APHIS have summarized agency program activities in detail. State agricultural experiment stations and the Cooperative Extension System have generated numerous research and educational publications.

Significant progress is being made to develop effective control measures for the Russian wheat aphid. Natural enemies of RWA have been collected throughout the world and are being evaluated for potential use in the United States. Environmentally safe and compatible pesticides are being evaluated for use as a temporary crop protection tool. Progress is being made on the development of Russian wheat aphid resistant crop varieties. Understanding of the Russian wheat aphid's life cycle and feeding habits is providing information for changing crop management practices to minimize economic damage. Educational programs for producers have been initiated in all impacted states. Timely development of effective control practices is essential to stop further spread of the pest and to protect the nation's cereal grain industry.

---

[1] Melvin D. Skold, Executive Director, Department of Agriculture and Resource Economics, Colorado State University, Fort Collins, Colorado 80523.

Budget Summary

Timely development of effective Russian wheat aphid control practices to protect the nation's small grain supply is essential for a secure food and feed resource. Small grains are an important part of our basic nutritional diet as well as for populations throughout the world. Other nations rely on U.S. cereal production which translates into essential trade products for the export and balance of payment.

States and agencies have reallocated significant resources to protect crops from the Russian wheat aphid. However, additional funds are needed to address the pest problem and avert future crop loss. Congress has provided a portion of requested funds in the past three years but at a level below critical needs. The National Russian Wheat Aphid Steering Committee has prepared a multi-agency budget which reflects resource requests to allow program development and delivery for the nation's small grain producers.

The total federal appropriated funds in FY91 were $2.95 million. This represents 31 percent of the needed funds required for a full-scale implementation of the RWA-IPM program. Appropriations below the requested funding level have resulted in the inability of agencies to respond to this national emergency in a timely manner.

Financial Resources Needed

National Russian Wheat Aphid Integrated Pest Management Program Budget Summary ($ × 1,000).

Program components	Agency	FY1	FY2	FY3	FY4	FY5	FY6	FY7	FY8	FY9	FY10	TOTAL
Biology and Ecology	States	$ 450	$ 450	$ 450	$ 450	$ 300	$ 300	$ 300	$ 300	$ 300	$ 300	$ 3,600
	ARS	300	300	300	300	300	300	300	300	300	300	3,000
	Subtotal	750	750	750	750	600	600	600	600	600	600	6,600
Host Plant Resistance	States	550	550	550	400	400	400	400	400	400	400	4,450
	ARS	400	400	400	400	350	350	350	350	350	350	3,700
	Subtotal	950	950	950	800	750	750	750	750	750	750	8,150
Insecticide Mgmt.	States	700	700	700	700	700	700	700	700	700	700	7,000
Biological Control	ARS	400	400	400	475	600	600	600	600	600	600	5,275
	States	750	750	750	1,000	1,000	1,000	1,000	1,000	1,000	1,000	9,250
	APHIS	3,175	3,175	3,175	3,000	3,200	3,200	3,200	3,200	3,200	3,200	31,725
	Subtotal	4,325	4,325	4,325	4,475	4,800	4,800	4,800	4,800	4,800	4,800	46,250
Integrated Pest Management System	States	950	900	900	900	900	900	900	900	900	900	9,050
	ARS	850	900	900	900	900	900	900	900	900	900	8,950
	Subtotal	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	18,000
Economics	ES	200	200	200	200	75	75	75	75	75	75	1,250
Info. & Tech Transfer	ES	775	775	775	775	775	775	775	775	775	775	7,750
Total		$9,500	$9,500	$9,500	$9,500	$9,500	$9,500	$9,500	$9,500	$9,500	$9,500	$95,000
Total/Agency	ARS	$1,950	$2,000	$2,000	$2,075	$2,150	$2,150	$2,150	$2,150	$2,150	$2,150	$20,925
	States	3,400	3,350	3,350	3,450	3,300	3,300	3,300	3,300	3,300	3,300	33,350
	APHIS	3,175	3,175	3,175	3,000	3,200	3,200	3,200	3,200	3,200	3,200	31,725
	ES	975	975	975	975	850	850	850	850	850	850	9,000

Budget Request FY92

Agency	FY89*	FY90*	FY91*	FY92*
ARS	$ 0	$ 750	$ 200	$1,950
SAES	100	350	350[a]	3,400
APHIS	0	1,000	2,400[b]	3,175
CES	0	0	0	975
	$100	$2,100	$2,950	$9,500

*($ × 1,000)

[a]Directed to California, Washington, Idaho and Oregon.

[b]$1 million increase with $1.4 million redirected funds.

WRCC-66, "Biology and Control of Russian Wheat Aphid"

Summary

Edited by Susan E. Halbert, President, WRCC-66

February 20, 1991

Russian wheat aphid is a new pest in North America which has been responsible for over a quarter of a billion dollars in loss for growers over the past three seasons. The pest threatens all classes of wheat and barley. Nearly all of the wheat acreage and barley acreage in the Western United States is at risk. Failure to protect cereal crops from Russian wheat aphid could result in inadequate global supplies of wheat and barley.

Russian wheat aphid also jeopardizes profitability of producing small grains. Decreased yield (up to 70%) and a substantial increase in the need for insecticide treatment have cut sharply into the already limited returns expected from small grain production. Besides reducing profitability, increased insecticide usage may also cause outbreaks of secondary pests, cause buildup of insecticide-resistant insect populations, pose a threat to farm workers, sportsmen and wildlife and increase the risk of groundwater contamination.

The goal of the Russian wheat aphid management program coordinated through WRCC-66 is to provide sustainable management strategies which minimize cost to the grower and do not adversely affect the environment. The foundation of this approach will include biological control, development of plants resistant to the aphid and discovering cultural management practices which maximize production and profitability and minimize crop exposure to infestation.

Considerable progress has been made to date. In the area of host plant resistance, good sources of resistance have been found in barley, wheat and triticale. Plant breeders are now working to incorporate the genes into locally adapted varieties.

Numerous expeditions have been carried out to areas where Russian wheat aphid is native. Most explorers have found that the aphid is under good natural control in its native range. More than 70 separate populations of natural enemies have been collected, processed through quarantine and cultured. Most, with the exception of some of the newest acquisitions, have been released at least once. It is usually possible to find specimens a few weeks after release, but it is too early to know which of these will become permanently established in North America.

Registered and unregistered insecticides have been subjected to an extensive screening effort. This has resulted in several new local registrations and the possibility for general registration of some products in the near future.

There is currently a major effort to devise efficient sampling techniques for Russian wheat aphid and develop accurate economic threshold models which account for economic and biological variation. Incorporation of research on basic biological parameters such as cold tolerance, temperature specific growth rates and host range will add to the reliability of the models.

The Western Regional Suction Trap Survey System has been very useful for alerting growers about the potential for Russian wheat aphid infestations and for tracking geographic range expansion. The combination of trap collection-based management thresholds and local field surveys will provide a more accurate means of predicting the potential for infestations, enabling growers to make more timely and efficient control decisions.

Releases of agronomically acceptable resistant varieties in most classes of small grains are expected within the next five years. It is also expected that some of the released natural enemies will become well established by then, at least in some states. In the future, an integrated approach, emphasizing sustainability, will be stressed. Plant resistance, biological control and appropriate cultural management practices will be incorporated into a regional Russian wheat aphid management decision support system. Producers will have access to the information through the Cooperative Extension System, state newsletters and the public media.

WRCC-66, "Biology and Control of Russian Wheat Aphid"

Authors:

Frank E. Gilstrap, Texas A&M University
Susan E. Halbert, University of Idaho
Gary L. Hein, University of Nebraska
Gregory B. Johnson, Montana State University
G. J. Michels, Texas A&M University
Frank B. Peairs, Colorado State University
C. Michael Smith, Kansas State University

February 20, 1991

Introduction

Russian wheat aphid is a new pest in North America which has been responsible for over a quarter of a billion dollars in cost to growers over the past three seasons (1987-89). It was introduced into Mexico in the late 1970's or early 1980's and was first discovered in the United States in the early spring of 1986. Since then its range has expanded to include 17 Western states and three Canadian provinces. The Russian wheat aphid is native to Central Asia and possibly the Middle East. A world-wide distribution now includes every major cereal producing region except Australia.

Russian wheat aphid threatens all classes of wheat and barley and can also cause losses in rye and triticale. Nearly all of the wheat acreage and barley acreage in the Western United States is at risk. Yield losses up to 70% have been reported, and some crops have been damaged so badly they were never harvested. Estimates of losses for the 1990 season are not available yet; however, preliminary indications are that Russian wheat aphid was less of a problem in the southern part of its range and much more serious in the north, especially in Washington, Oregon, Idaho, Nebraska and Wyoming.

Wheat is a world-wide staple food crop, important both for domestic consumption and as a major component of the global food supply. Wheat is also an important American export product. Failure to protect cereal crops from Russian wheat aphid could result in inadequate supplies of wheat and barley to serve domestic and international markets and could threaten American ability to compete in a global economy. Inadequate supplies of wheat or a significant increase in price could make this staple food unaffordable or unavailable to the world's poor.

Throughout much of the United States, small grain production is only marginally profitable. Prior to the introduction of Russian wheat aphid, insecticides were rarely used on small grains. In some cases, growers must now apply up to three insecticide treatments to control Russian wheat aphid. This substantial increase in need for insecticide treatment can, in some cases, reduce profitability to the point that it is no longer economically viable to produce wheat and barley. Increased insecticide use may cause outbreaks of secondary pests or insecticide resistance and may also pose a threat to farm workers, sportsmen and wildlife, including endangered species, and increase the risk of groundwater contamination.

The seriousness of the threat to one of North America's most important crops has resulted in unprecedented cooperation among U.S. federal and state researchers, Canadian researchers and international agencies, state agricultural experiment stations, the USDA's Agricultural Research Service, Animal Plant Health Inspection Service, Cooperative Extension System and Cooperative States Research Service, the state departments of agriculture, the National Plant Board, the National Association of Wheat Growers, the National Agricultural Chemicals Association, state wheat and barley commissions, Agriculture Canada, Alberta Agriculture, Saskatchewan Agriculture Department, CIMMYT, ICARDA and the Commonwealth Institute of Biological Control. These agencies have all actively participated in an effort to develop economically viable management strategies for Russian wheat aphid. In many cases sacrifices have been made in redirecting limited funds toward Russian wheat aphid research.

Substantial progress to date would have been impossible without the cooperation achieved in this effort.

The goal of this wide ranging cooperative program on Russian wheat aphid pest management is to provide profitable management strategies which minimize the need for recurrent chemical intervention. So far, pesticides have been the only option for Russian wheat aphid management. In the future an integrated approach more in line with modern concepts of Low Input Sustainable Agriculture (LISA) will be developed. The foundation of this approach will include biological control, development of plants resistant to Russian wheat aphid and discovering cultural management practices which maximize production and profitability and minimize crop exposure to infestation.

This report summarizing substantial progress to date and delineating future plans and benefits includes chapters on host plant resistance, biological control, biology and ecology, insecticide management, integrated pest management and information and technology transfer. Chapters were written by the WRCC-66 section chairmen. A list of publications and presentations by committee members also is included.

Reports of Progress

BIOLOGY AND ECOLOGY

Objectives

Basic Biology

* To determine Russian wheat aphid reproductive and developmental thresholds at constant temperatures on wheat, and compare these parameters to other small grain aphids in the High Plains.
* To determine the best laboratory media for rearing Russian wheat aphid.

Dynamics of Field Infestations

* To monitor Russian wheat aphid flight activity.
* To determine the potential for reinfestation in the spring or fall of those areas where Russian wheat aphid did not overwinter or oversummer successfully.
* To estimate population levels of Russian wheat aphid in winter wheat and spring barley.
* To develop numerical and binomial sampling plans for the Russian wheat aphid in winter wheat and spring barley.

Overwintering Capabilities

* To monitor and model overwintering of Russian wheat aphid in the field. To determine the supercooling points (freezing points) of Russian wheat aphid. To determine the effect of sub-lethal freezing temperatures on Russian wheat aphid survival and reproduction.
* To determine prevalence of Russian wheat aphid sexuals in the field.

Non-Crop Hosts

* To determine the impact of Russian wheat aphid on Conservation Reserve Program grasses and other dryland grass species.
* To determine whether grasses used in U.S. government soil conservation programs serve as reservoirs of Russian wheat aphid.

Interactions Between the Russian Wheat Aphid and Its Physical and Biotic Environment

* To determine the influence of water stressed wheat on Russian wheat aphid development in the field.
* To study Russian wheat aphid increase in dryland wheat and relate it to the presence of aphid competitors and beneficial insects.
* To evaluate the influences of downy brome infestation and fertility on Russian wheat aphid damage in winter wheat.
* To monitor local populations of Russian wheat aphid to determine whether they develop capability to transmit barley yellow dwarf virus (BYDV).
* To assess the impact of Russian wheat aphid chemical control activities on non-target organisms.
* To evaluate the effect of planting date on Russian wheat aphid incidence and intensity.
* To evaluate the effect of cattle grazing of winter wheat on Russian wheat aphid populations.

Current Activities

Surveys

Most states have ongoing survey programs using field scouting, suction traps and occasional pan traps. The surveys are used in extension programs to warn growers. They also have been used to document range expansion and population fluctuations. The current research focus is on correlating data from trap surveys with field observations.

Basic Biology

Much of the preliminary work on developing life tables and temperature related population growth rates has been completed. Current research in the area of basic biology emphasizes population development under simulated field conditions and development of laboratory media for rearing Russian wheat aphid.

Overwintering Capabilities

Several states as well as Alberta, Canada, have research programs on overwintering capabilities of Russian wheat aphid. Research is being conducted on cold tolerance, winter distribution as a function of microclimate, the role of cryoprotectants and the occurrence of sexuals.

Non-Crop Hosts

Current research on grass hosts assesses both potential damage to rangeland grasses and the potential for those grasses to serve as reservoirs of Russian wheat aphid during the winter and in the summer dry season.

Interactions with Biotic and Abiotic Factors

Research on interactions between Russian wheat aphid and other factors and organisms is varied, but generally focuses on those interactions which have potential economic importance.

State Reports

Colorado

Research is being conducted on the distribution of Russian wheat aphid in wheat during the winter as influenced by microclimate. The supercooling points of Russian wheat aphid are being determined, and the role of cryoprotectants in Russian wheat aphid overwintering is being investigated.

A number of grass species have been classified as to their suitability as hosts for Russian wheat aphid.

Russian wheat aphid flight activity is monitored with a series of 20 Allison-Pike suction traps.

Pheasant chicks have been exposed to commercial applications of chlorpyrifos and disulfoton. The presence of nontarget insect species was assessed in the same experiments with sweep net and pitfall samples.

The influence of N and P fertilization on Russian wheat aphid population increases is being evaluated in both greenhouse and laboratory experiments.

The effect of winter wheat planting date on Russian wheat aphid is being studied in both controlled field experiments and extensive surveys.

The effects of cattle grazing, planting date and variety on Russian wheat aphid populations have been evaluated.

Idaho

Replicated plots including 25 conservation grasses and wheat have been established at Parma and Kimberly under irrigated and dryland regimes. These are being sampled in the early spring to detect overwintering Russian wheat aphid, mid-season during peak Russian wheat aphid flights, in the summer dry season to detect potential sources of Russian wheat aphid prior to fall planting season, and in the fall to detect potential sources of infestation for fall crop and potential overwintering populations.

So far there is little to no evidence that Russian wheat aphid is a significant vector of BYDV in North America; however, selection pressure for vector capability is great. Monitoring naturally occurring populations in Idaho for transmission will continue, and efforts will be intensified in years when outbreaks occur of either Russian wheat aphid or BYDV or both.

Suction trap catches are being correlated with local infestation levels. The suction trap network has been useful in tracking range extension of Russian wheat aphid throughout Idaho, for alerting growers to the potential for infestation of spring-sown cereal crops and for advising safe fall planting dates.

Montana

Research is being done on the use of benzimidazole agar to keep leaf pieces alive for rearing Russian wheat aphid in growth chambers. The technique can be used to do life table analyses of biological control agents.

Two winter fields and one spring barley field were sampled at approximate weekly intervals during June and July 1990 and the number of Russian wheat aphids per tiller was determined. The sample size (number of tillers) necessary to maintain a 15% error level (sample error/mean) was determined for each field and sampling date by taking five random tillers in each of 20 locations within the respective fields sampled. The mean and variance of the number of Russian wheat aphid per tiller were then used in an optimal sample size formula to determine the number of additional tillers necessary to achieve the 15% error level. Error levels obtained using this approach ranged from 8 to 10%. Taylor's Power Law Analysis was then conducted on the mean and variance values obtained and numerical and binomial sampling plans were generated for Russian wheat aphid that was infesting winter wheat and spring barley.

The Russian wheat aphid population reached a peak density of 48 aphids per tiller in winter wheat during the third week in June. In contrast, Russian wheat aphid population in June for spring barley were generally low, but rapidly increased to a peak of 136 aphids per tiller the third week in July.

Nebraska

Spring barley trap crops are being used to monitor for Russian wheat aphid activity through the spring each year. Russian wheat aphid infesting the barley can be rapidly detected because of the severe and rapid development of leaf yellowing. Flight activity of Russian wheat aphid is also being monitored with yellow water-pan traps and suction traps. Spring populations were not present in the plot areas or in the surrounding counties. Flights of Russian wheat aphid have been detected in late May-early June in 1988 and 1989.

Texas

Research on the effect of drought stress on Russian wheat aphid bionomics is being done in the field by excluding rainfall to produce varying degrees of drought stress. In 1990, preliminary research was conducted in a rainout shelter to develop techniques using wheat grown at several available water levels. Based on this experience, the study will be modified and continued in 1991.

Research evaluating the effects of humidity on the bionomics of Russian wheat aphid is planned for the near future. The studies will compare the effects found to those of other small grain aphids.

Wyoming

Research plots were established on the University of Wyoming Research and Extension Centers at Archer and Torrington for the 1989 cropping season. Plots represented all possible combinations of two levels of downy brome infestation and three levels of fertilizer application. Chlorpyrifos was used on one half of each plot to produce an aphid-free control.

Two studies were conducted in 1989 to determine the impact of Russian wheat aphid on grasses recommended for use in the Conservation Reserve Program along with other dryland grasses commonly grown on Wyoming native rangelands. The first study was a field trial, and the second was a complementary greenhouse trial. The field trial consisted of 30 grasses that were adapted to dryland production. These grasses were seeded into plots of fallow seedbed on April 18, 1989, and good stands of all grasses were obtained. Half of the seeded area (two of four blocks) was sprayed with dimethoate at 3/4 pint per acre in late May, late June and late July. The greenhouse study consisted of planting selected grasses in pots and infesting them with 10 Russian wheat aphids per pot (one grass plant per pot).

Preliminary results indicate that the numbers and distribution of Russian wheat aphid, as well as symptoms, are all extremely variable; however, some grasses, including "Fairway" crested wheatgrass and "Manchar" smooth bromegrass, appeared resistant.

Russian wheat aphid seemed to increase most successfully on mammoth wildrye, bluebunch wheatgrass, intermediate wheatgrass, pubescent wheatgrass and tall wheatgrass. Russian wheat aphid numbers on western wheatgrass and slender wheatgrass were slightly lower. Mountain brome was infested with Russian wheat aphid on all observation dates.

Alberta, Canada

Supercooling points have been established. A threshold for development has been established and compared to other published thresholds. Survival and development after exposure to constant freezing temperatures have been examined. Russian wheat aphid populations are being monitored in the field. Periodic collections are being assessed to determine the seasonal changes in cold tolerance of Russian wheat aphid. Field information is being compared to data already accumulated using lab-reared aphids.

Future Emphasis

In the area of basic biology, researchers hope to evaluate the effects of humidity in a manner similar to the temperature studies. The effects will be compared to those found with other small grain aphids. There are also plans to determine the effect of water stress on Russian wheat aphid bionomics and damage potential, to determine the effect of preconditioning of aphids at temperatures close to the developmental threshold on cold tolerance and to model the survival and development of overwintering populations. Future studies will also be directed at determining if wheat vigor or canopy reflectance influences the attractiveness of wheat to the aphid. Finally, bionomic studies will be expanded to include the effects of other aphid species and beneficial insects on growth, development and movement of Russian wheat aphid.

Making use of the extensive Western Regional Suction Trap Network, the timing of flights and the propensity toward long range or local flights will be studied. One potential use of the suction trap data also may be the development of indices based on cumulative seasonal trap collections for area-wide yield loss caused by Russian wheat aphid.

Winter wheat and spring barley fields will be sampled again in 1991 to determine Russian wheat aphid population levels throughout the growing season in many western states. Mean and variance relationships (estimated from the number of Russian wheat aphids per tiller) generated in 1990 and 1991 will be compared among crops and among states and Canadian provinces. The data will be used to develop regional numerical, binomial and binomial-sequential sampling plans.

Current research on the effect of Russian wheat aphid on the vigor of conservation grasses will be expanded to include the effect of the aphids on seed and forage production. Other possible future emphases may include investigation of basic questions such as biochemical characteristics of host acceptability, incorporation of resistance genes into wheat through wide crosses or use of conservation grasses as reservoirs for biological control agents of Russian wheat aphid.

Potential Benefits

The potential benefits of Russian wheat aphid biology and ecology research will be felt largely in improved management strategies due to modified cultural practices and a better ability to predict changes in Russian wheat aphid populations. The suction trap survey system has already been very beneficial for alerting growers about the potential for Russian wheat aphid infestations. Refinement of trap-based management thresholds will

provide an even more useful service. If counts can be used to provide an index of aphid related crop loss, this could be beneficial to economists and agricultural strategists.

Cereal producers will know which, if any, of the conservation grasses constitute potential oversummering or overwintering reservoirs of Russian wheat aphid. Grasses which show promise as reservoirs of natural enemies of Russian wheat aphid could be incorporated into large scale Low Input Sustainable Agriculture (LISA) systems. Basic information on host/non-host characteristics could be incorporated into development of future resistant crop varieties or exploited to prevent aphids from recognizing their host plants.

Research on Russian wheat aphid bionomics in the field and in the laboratory can ultimately be used to formulate developmental models. Models such as one being developed in Canada, which will predict the potential for overwintering in Canada and the northern United States, will be used to warn farmers of the likelihood of spring infestation in winter and spring cereals.

Currently, there is great interest in reducing the number of stress factors that could exacerbate the effects of Russian wheat aphid. Certain weeds, such as downy brome, may harbor Russian wheat aphid and provide a source of infestation for crop seedlings. Results of research in this area could be used to adjust the timing of weed control applications to decrease the potential for Russian wheat aphid infestations.

The benefits of the wide ranging program on Russian wheat aphid biology and ecology are many. In summary, as a result of ongoing research in the Western United States and Canada, more accurate means of predicting the potential for infestations will be developed. These will enable growers to make more timely control decisions. Research on winter and summer dry season reservoirs of Russian wheat aphid will lead to the development of cultural management strategies which maximize production while avoiding unnecessary crop exposure to infestation.

Implementation

Preliminary results of many of the projects in this chapter have already been presented at meetings scientists and industry personnel. Some studies have been published in scientific journals and extension publications. Several states have a weekly newsletter alerting growers about the potential for Russian wheat aphid infestations. Commercial media also has been used extensively when situations warrant immediate dissemination of information to the public. Information on bionomics, field population dynamics and sequential sampling will be incorporated into a Western Regional Decision Support System for Russian wheat aphid management being developed at Bozeman, Montana, in cooperation with most of the other states in the region.

INSECTICIDE MANAGEMENT

Objectives

* To develop longer duration of control.
* To determine application timing for greatest economic return.
* To develop applications with ground and aerial equipment.
* To develop acceptable grazing allowances.
* To develop environmentally compatible integrated usage with low risk to man and animals.
* To develop strategies to prevent or delay the development of resistance in Russian wheat aphid to effective insecticides.

Current Activities

Many registered and unregistered insecticides are being tested by land-grant universities, U.S. and Canadian agencies and industry with the intent of identifying products which provide longer duration of control than is now achieved by small grain producers with currently registered treatments.

The timing of insecticide applications must be based on an economic threshold which is based on a documented economic injury level. The use of economic thresholds is the cornerstone of sound insect pest management. Investigators in California, Colorado, Montana (MSU and USDA-ARA), Texas and Washington have initiated a joint effort (funded through WR-160, CSRS Special Grants Programs) to develop economic injury levels and economic thresholds for Russian wheat aphid across its U.S. geographic distribution. Parallel efforts are underway to develop the Russian wheat aphid sampling schemes needed to assess aphid populations for the injury level and threshold calculations.

Little has been done to improve ground and aerial foliar insecticide application technology (spray volume, spray adjuvants, nozzles, droplet size, etc.). Several spray adjuvants have been tested and limited studies have been conducted of the effect of spray volume on the level of Russian wheat aphid control. Planting-timing insecticides in the form of conventional granules, slow release granules, microtube injected liquids and seed treatments have shown promise as new means of applying Russian wheat aphid insecticides for long-term control in winter grains.

Any work on grazing allowances is being done by industry.

Pheasant chicks have been exposed to commercial applications of two most commonly used Russian wheat aphid insecticides for two years in Colorado with little effect on this important wildlife species. The effects of the same applications on non-pest insects were also evaluated. Insecticides are being tested in Texas for their relative toxicity to Russian wheat aphid and to natural enemies of Russian wheat aphid.

Baseline toxicities of several insecticides to Russian wheat aphid have been measured. This information can be used to monitor the development of resistance. Seasonal changes in insecticide efficacy and the influence of ambient temperature on efficacy have also been studied. These factors might explain some control failures that might otherwise be attributed to genetic resistance to a given insecticide.

Future Emphasis

Substantial insecticide testing will continue, although the prospects for the development of new compounds are not great. It is likely that the number of registered insecticides will decrease, making even greater the needs for improving the efficacy of existing compounds and for insecticide resistance management.

Concerns for the effects of Russian wheat aphid insecticide applications on non-target organisms will increase. Application safety will have to be improved operationally given the limited number of available insecticides, their relative toxicity and the prospects for new materials.

The major emphasis will be placed on the development of computer-based insecticide application decision support systems which will take into account economic injury levels, control costs, presence of Russian wheat aphid natural enemies, crop condition and development, expected economic returns and climatic factors. Much research will be needed to develop these systems.

Potential Benefits

Properly timed and applied Russian wheat aphid insecticide treatments can result in yield savings of 50% or more. Given that more than 2 million acres have been treated yearly for Russian wheat aphid, the savings have likely been enormous. Much of this benefit is due to the insecticide research that has been conducted. As Russian wheat aphid treatment decision making improves, growers will benefit from fewer, more economically effective insecticide applications. Environmental benefits will derive from fewer treatments and operational modifications intended to minimize impacts on non-target organisms.

Implementation

Results of insecticide performance and application technology research are made available to growers and industry personnel through public meetings, personal contacts, and in-house and formal publications. This channel of information has been in place for years and is quite effective. The implementation of computer-based decision support systems may pose more of a challenge to Cooperative Extension, given its lack of appropriate equipment and experienced personnel. Insecticide resistance management programs may also pose a number of informational and policy challenges.

BIOLOGICAL CONTROL

Objectives

* To collect and import natural enemies from the aboriginal home of the Russian wheat aphid.
* To release and permanently colonize imported Russian wheat aphid enemies in all possible parts of the U.S.
* To evaluate the potential and actual impact of existing and new Russian wheat aphid enemies for biological control.
* To integrate biological control research results with other crop protection tactics.

Current Activities

The U.S. multi-agency program is comprised of 16 State Agricultural Experiment Stations (SAES), the USDA-Agricultural Research Service (ARS), and the USDA-Animal Plant Health Inspection Service (APHIS). Generally, each agency is engaged in the listed objectives, and WRCC-66 coordinates these activities. Specific agency activity: APHIS mass produces and in some states releases imported enemies, provides funds for international collection and SAES quarantine activity and sponsors a national data management activity; and SAES and ARS conduct the local research and most foreign collection of exotic RWA enemies. Non-member cooperators and contractors include State Departments of Agriculture, Agriculture Canada, Commonwealth Institute of Biological Control and many foreign-based scientists.

A three-phase plan is set to implement Russian wheat aphid biological control. Each implemented phase continues as the next phase begins. Phase I of the WRCC-66 biological control program began in August 1988, with importation of five species of Russian wheat aphid parasites. Since then, several SAES and ARS

scientists have travelled to numerous countries where Russian wheat aphid originated. These scientists collected enemies and trained collaborators for future collecting. Collected enemies are shipped to SAES or ARS quarantine facilities where they are used to start cultures of the enemies. These cultures then produce enemies for field release. Russian wheat aphid exists in a wide range of weather extremes and in very different cropping systems. Thus, optimal success of Russian wheat aphid biological control will require that many types of Russian wheat aphid enemies be imported from all countries of where Russian wheat aphid occurs. Enemy release techniques have been developed to optimize success of permanently establishing Russian wheat aphid enemies in all parts of the U.S. Many Russian wheat aphid-infested states do not have facilities or personnel to produce large quantities of imported Russian wheat aphid enemies. Thus, APHIS produces imported enemies for these states and for cooperating agencies.

Phase II is the focus of current activity, and emphasizes collaborator and U.S. scientist collection of Russian wheat aphid enemies in prime areas for effective enemies. Repeated collections in key countries are necessary because the enemy complex attacking Russian wheat aphid changes as the wheat production season progresses. Phase II also emphasizes continued local research on aphid/enemy interactions, magnifies the program for release and field colonization of imported enemies and initiates development of research tools needed to evaluate the impact of released and extant Russian wheat aphid enemies.

Phase III began in earnest in 1989. It consists of domestic research needed to optimize biological control. Field studies in progress on Russian wheat aphid parasites and predators are diverse and include (1) measuring the population dynamics of aphids and enemies in key locations, (2) appraising the diversity of extant aphid enemies attacking Russian wheat aphid in the field, (3) verifying establishment of permanent populations of exotic enemies that have been released, (4) determining the extent of mortality from extant enemies, (5) assessing the role of Conservation Reserve Program areas in aphid/parasite population dynamics, (6) determining overwintering capabilities of released exotic enemies and (7) assessing the potential of extant pathogenic organisms that can cause disease in Russian wheat aphid populations. Domestic laboratory studies are developing tools to (1) distinguish between closely related exotic and extant enemies (i.e., using DNA analysis, electrophoresis or biological characteristics), (2) anticipate which exotic enemies each locale should emphasize for optimal chances of establishment, (3) produce developmental biology for Russian wheat aphid enemies present in local populations of Russian wheat aphid and (4) provide understanding to optimize the value of biological control.

Specific Progress

Objective 1: Import natural enemies from the aboriginal home of the Russian wheat aphid. To date, more than 150 Russian wheat aphid enemies have been processed through federal and state quarantine facilities, including enemies from Burundi, Czechoslovakia, France, Greece, Holland, Iran, Iraq, Jordan, Morocco, Pakistan, Peoples Republic of China, Poland, Spain, Syria, Turkey, U.S.S.R. and Yugoslavia. More than 70 of these imported Russian wheat aphid enemies have been cultured, many have been field released at least once, and at least 15 have been released many times. Cooperating agencies are culturing more than 53 different Russian wheat aphid enemies. Some of these cultured enemies are so recently imported that they have not yet been released.

Objective 2: Release and colonize imported enemies in the U.S. The first imported Russian wheat aphid enemies were imported in fall 1988. Within several months, many research agencies and APHIS began production of these first enemies. About 100,000 exotic aphid parasites and 576,000 exotic predators were produced and released in 1989; and about 612,000 exotic parasites and 431,000 exotic predators were produced and released in 1990. These nearly 1.5 million Russian wheat aphid enemies were sent in about 500 shipments to cooperators for release in about 25 sites (at least one site in each of 16 states and in Canada).

Objective 3: Evaluate impact of Russian wheat aphid enemies. Research was initiated in 1990 to (1) use electrophoresis, behavior and reproductive isolation to identify indigenous and exotic populations of two species complexes, *Aphelinus sp nr varipes* and *Diaeretiella sp nr rapae*, prominent candidates controlling Russian wheat aphid, (2) develop check methods for evaluating respective enemies for impact on Russian wheat aphid and other wheat infesting aphids and (3) determine adverse effects of currently registered insecticides against extant and exotic Russian wheat aphid parasites.

Objective 4: Integrate biological control research results with other crop protection tactics. Many aspects of current research will apply this objective, but little integration is possible until greater understanding is available. However, discussions on integration began in 1990, and continuance of these discussions will be critical to biological control developing needed information to facilitate integration.

Future Emphasis

Collection, importation, culture, distribution and field release of exotic enemies were the initial goals of biological control. These activities are sustaining, and

major remaining tasks are to (1) establish in the field one or more efficacious enemies, (2) measure the Russian wheat aphid population suppression by new and existing enemies and (3) perfect tools for distinguishing between enemies that look identical but are biologically different. The ultimate goal of biological control is to optimize the impact of effective Russian wheat aphid enemies when used with other effective crop protection tools, and to provide farm-level information needed to integrating these tools in a cost-effective system of crop production.

Potential Benefits

Biological control is a distinct prospect for unilateral and complete control of Russian wheat aphid. If biological control is only partially successful, it is historically completely compatible with all other non-insecticide tools. Regardless of the extent of biological control success, costs for continued biological control will diminish to those required to integrate biological control with other tactics.

Implementation

The use and coordination of biological controls in crop protection are being implemented as WRCC-66 research progresses. If biological control can be a unilateral control, very little additional research will be required for effective implementation at the farm level. If biological control is partially successful and must be used in concert with other crop protection tactics, information collected in Phases II and III will provide the understanding needed to integrate biological control with other tactics.

INTEGRATED PEST MANAGEMENT

Objectives

* To incorporate the knowledge and information obtained in research on biology, ecology, host plant resistance, biological control, cultural control and insecticidal control into an integrated approach to managing the Russian wheat aphid.
* To develop a comprehensive decision support system for Russian wheat aphid on wheat that addresses differences in Russian wheat aphid-plant interactions as affected by production systems, geographic location, plant age and multiple biotic and abiotic stresses. Initial focus: To determine the influence of plant stage and aphid density on plant damage.
* To assess the economic threshold and injury levels for the Russian wheat aphid in spring barley.
* To develop an efficient sampling plan utilizing numerical and binomial sampling plans for Russian wheat aphid in wheat and barley.
* To develop fall thresholds and sampling plans.

Current Activities

A multi-state integrated pest management research group, including cooperators in Texas, Colorado, Montana, Washington and California (Tom Archer, project leader), is currently determining the effect of plant growth stage on Russian wheat aphid damage. Similar experimental protocol is being used in each participating state. This will increase the data base and optimize the application of these data across the entire region. Planting date and Russian wheat aphid levels will be varied and the impact of the aphid infestation on the plants will be measured. The initial phases of this research will focus on studying the plant response to aphid feeding in small plots using artificial infestation techniques.

A number of other states are independently collecting data on the yield loss relationship for the Russian wheat aphid to determine local threshold recommendations. This larger data base will be valuable in developing and verifying the regional decision support system.

Three barley cultivars were planted at four locations in Wyoming. Varying rates of insecticides were applied at different plant growth stages to establish different aphid densities. Plant measurements were taken to determine the impact of the Russian wheat aphid on barley growth. The data provide information on the economic threshold for Russian wheat aphid on feed barley based on stage of plant growth.

In a multi-state sampling project (David Legg, project leader) data were used from spring and summer Russian wheat aphid infestations in winter wheat and spring barley in Colorado, Nebraska, Oklahoma and Wyoming to determine the relationship between the proportion of infested sample units and the mean number of aphids per tiller using five binomial regression models. A similar sampling program in Montana includes sampling winter wheat and spring barley through the season to determine Russian wheat aphid levels. Mean and variance relationships will be compared among crops and states or provinces.

Future Emphasis

The future emphasis of integrated pest management research dealing with the Russian wheat aphid will be to integrate all aspects of insect control into a workable management system. The components of this system will be host plant resistance, cultural control, biological control and insecticidal control.

The research on the multi-state integrated pest management project will be expanded with increased funding to incorporate abiotic stress, biological control, multiple aphid infestations, wheat varieties (especially resistant varieties) cultural practices and spring wheat and barley into the decision support system. Research

comparing suction trap collections with field infestation will allow incorporation of trap collection data into the system. The data generated in this project will be used by Jim Berry (USDA-ARS, decision making process) and Norm Elliott (USDA-ARS, insect/plant model) to develop and refine the system. The implementation of this decision support system will require a large and diverse data base for the verification and fine tuning required to make it useful on a wide scale.

Future studies on spring barley economic thresholds will be conducted under irrigated conditions to ensure malting quality. These studies will be conducted to determine how the Russian wheat aphid influences yield as well as malting quality.

The binomial models developed from the multi-state sampling project will be compared to those from data collected on fall-infested winter wheat. These models will also be compared to those derived from data collected with a consistent 15% level of precision. Simulation sampling experiments will be conducted to thoroughly test the sensitivity of test models to changes in sample size. Mean and variance relationships will be compared among crops and among states. Regional numerical, binomial and binomial-sequential sampling plans will be developed.

Potential Benefits

All of the research underway on the Russian wheat aphid has at least an indirect relationship to the development of efficient management strategies. Integrated pest management research is the mechanism by which the data obtained in the laboratory, greenhouse or field are transferred into information meaningful to the small grains grower. Data from host-plant resistance, biological control and insecticide, biological, ecological and damage threshold studies are integrated and evaluated as to their importance in the management system.

The development of sampling plans that can be used to reach a decision more efficiently will improve the grower's ability to accurately identify fields where the damage potential is high. In addition, efficient use of sampling resources will improve economics of sampling and increase the acceptance of the recommended practice of regular scouting for aphid infestations. Currently, Russian wheat aphid management relies almost entirely on the use of insecticide treatments to reduce the potential for economic damage. Many thresholds that are utilized are based on a limited data base that has limited application. Other thresholds that are used are merely nominal "best guess" thresholds supported by little or no data. The early benefits of increasing the economic threshold data base will be to make the application of insecticides more efficient, thus eliminating unnecessary treatments. These savings will have a major impact on the economics of growing wheat in the Russian wheat aphid-infested areas. In addition, the reduced number of insecticide treatments will reduce the impact of insecticide treatments on the environment.

The long range goal of the multi-state economic threshold research group is to develop a comprehensive decision support system. Because the development of the decision support system will be a region-wide effort, the utility of this mechanism will be extensive. This decision support system will be flexible and will apply to a variety of production systems, weather patterns, geographic locations and changing economic conditions. This process will be the basis for the Russian wheat aphid integrated pest management system. Within this framework new research information can be readily incorporated to update the management system.

Implementation

The results of the studies mentioned will be presented at scientific meetings and published in scientific journals. These activities will inform the scientific community of the results of these studies and also will serve as a check on the quality of the research.

The information from these studies will also be utilized in all Russian wheat aphid-infested states as a basis for the development of extension recommendations. Russian wheat aphid management recommendations will be disseminated via extension publications, programs, newsletters and the media (including television, radio, newspapers and popular journals).

The development of a decision support system will be used by extension personnel, agriculture consultants and small grains growers. This mechanism will enable these individuals to utilize the expertise that has been developed into the decision support system to make well informed judgments as to the proper management decisions.

DISSEMINATION OF INFORMATION

Objective

* To inform and educate producers, field personnel and extension and research personnel as well as the concerned public of current developments with the Russian wheat aphid regarding distribution, detection and management.

Current Activities

Newsletters that contain information pertaining to Russian wheat aphid infestation levels and locations, suction trap catches, management strategies, biology and ecology are published by several states (California, Colorado, Idaho, Montana, Nebraska, Texas and

Wyoming). Newsletters are distributed to county extension offices, small grains producers, small grains organizations, agribusiness personnel and Russian wheat aphid researchers located throughout the western U.S.

Montana has developed a Russian Wheat Aphid Hotline with an in-state toll free number that operates from April through October. The hotline has a two to three minute recorded message that is updated every 7 to 10 days. For each of the past three years over 700 phone calls have been registered with this service. The University of Wyoming has developed an electronic bulletin board that contains weekly accounts of Russian wheat aphid infestations as well as suction trap catches. This information is available to those with a computer and modem.

Aphid suction traps have been established in most western states to detect the onset of Russian wheat aphid flight activity in the spring and fall. Trapping efforts serve as an early warning system by alerting growers to potential Russian wheat aphid infestations in their area. Aphid suction trap data are published in newsletter formats by several states.

Extension entomologists from western states are members of the Great Plains Agricultural Council Russian Wheat Aphid Investigative Committee and have provided economic loss data for the annual report.

Numerous press releases have been generated by individual states on topics of general interest dealing with Russian wheat aphid. Radio public service announcements and television interviews directly related to Russian wheat aphid were reported by Nebraska and Montana. Two states (Montana and Colorado) have developed videos describing Russian wheat aphid biology, damage and management strategies.

Future Emphasis

Each state indicated that the previously mentioned "Current Activities" will be continued as the major emphasis of educational activities. In addition it was generally stated by several state cooperators that electronically-based data/information systems will be developed to provide the public with more immediate access to time-sensitive information. Computer-based decision support programs will be developed as binomial sequential sampling models and economic injury level equations become available.

Potential Benefits

The benefits from having well-informed grain producers and agribusiness personnel are numerous. The tangible benefits of Cooperative Extension efforts have been the yield savings from properly timed insecticide applications and in production costs saved by avoiding unnecessary insecticide treatments. The benefit to the producer is that management decisions being made are based on the latest information available. Accurate management decisions are critical to the long term viability of wheat growers in areas continuously threatened by Russian wheat aphid.

Implementation

It is vital to keep growers, consultants and agribusiness personnel up to date on current research activities dealing with Russian wheat aphid management. Dissemination of educational information will be accomplished through grower meetings/workshops, development of educational bulletins and newsletters. Future impacts will be made through electronic bulletin boards and computer models, with the latter located at the county level.

ECONOMIC IMPACT

Through the 1988 growing season it was estimated that the Russian wheat aphid had been responsible for $184 million in losses from control costs and yield reductions (Peairs et al. 1989). This estimate is based upon economic impact studies by the Great Plains Agricultural Council Russian Wheat Aphid Investigative Committee (Morrison et al. 1988, Peairs et al. 1989). Because of the rapid spread of the Russian wheat aphid, infested areas in the western U.S. in 1988 included 28 million acres of small grains (Peairs et al. 1989). This third economic impact study covering the 1988-89 winter and spring small grains growing season was approved by the Crops and Soils Subcommittee because of the continuing severe impact of Russian wheat aphid.

The economic impact of the Russian wheat aphid for the 1988-89 small grains growing season is estimated at over $92 million (Tables 1-4). The data gathered for this assessment were obtained from questionnaires sent to members of the committee and to entomologists from those states not represented on the committee. Of the 34.4 million acres of winter wheat grown in the western U.S., 51% (16 million acres) of the dryland wheat and 75% (2.6 million acres) of the irrigated acres were grown in areas infested with the Russian wheat aphid (Table 1). The higher percentage for irrigated wheat is likely due to a greater proportion of irrigated wheat grown in the drier areas where the aphid seems to survive best. Only 11% (1,293,000 acres) of the spring wheat and 37% (2,100,000 acres) of the barley were grown in Russian wheat aphid-infested areas. The lower percentages for the spring planted grains are the result of a vast majority of these small grains produced in the northern Great Plains (Montana, North Dakota and South Dakota) where the aphid has not yet had an economic impact.

The Russian wheat aphid has not developed into a major pest of other small grain crops. No states reported significant yield reductions for oats, rye or triticale as a

result of Russian wheat aphid infestations. Only Texas (1,000 acres) and Wyoming (365 acres) noted any Russian wheat aphid treatments in oats. Wyoming also indicated that 37 acres of triticale were treated for Russian wheat aphid. It appears that significant infestations of these crops will develop only under isolated circumstances (e.g. early growth stage, extreme populations and ideal environmental conditions).

The number of acres treated for Russian wheat aphid in barley and wheat in 1988-89 was just over 2.2 million (Table 2). The total cost of these treatments amounted to nearly $21 million. About 7% of the treated winter wheat acres and 8% of the barley were treated more than once. Spring wheat (35%) required second treatments more often. Fall treatments made up 22% of the total winter wheat acreage treated, and ground treatments made up 5.5% of the total acres of all wheat and barley treated. Comments were received as to the difficulty of estimating ground treatment acres; therefore, ground treatments may be significantly underestimated.

Estimated yield reductions attributed to the Russian wheat aphid in 1988-89 totaled $71 million (Table 3). This loss figure was comprised of $55 million for winter wheat $5.4 million for spring wheat, and $10.4 million for barley. No other crops were noted as having significant yield reductions.

The total economic impact of the Russian wheat aphid during the 1988-89 winter wheat and 1989 spring grain growing season was $92.14 million (Table 4). These losses were intermediate in comparison to the two previous years. Approximately $4 million more was spent for aphid control than in previous years and only 64% as much yield reduction occurred. This indicates that controls are being used more effectively than in previous years. The total loss from the Russian wheat aphid in the U.S. has now accumulated to over a quarter of a billion dollars through 1989.

Table 1. Wheat and barley acreage and percentage of acres in Russian wheat aphid-infested areas in the western United States, 1989.

	Crop acreage (% in RWA Infested Areas) (x 1,000)			
	Winter wheat			
	Dryland	Irrigated	Spring wheat	Barley
Arizona	-	85 (56)	-	13 (69)
California	40 (25)	550 (55)	-	-
Colorado	2,200 (100)[1]		70 (100)	160 (100)
Idaho	569 (100)	231 (100)	330 (100)	840 (100)
Kansas	7,326 (52)	674 (72)	-	18 (-[2])
Montana	2,500 (35)	10 (0)	3,500 (20)	1,700 (45)
Nebraska	1,973 (61)	77 (87)	-	25 (60)
New Mexico	359 (100)	190 (100)	-	10 (100)
Nevada	-	8 (31)	14 (47)	33 (52)
North Dakota	130 (0)	-	4,700 (0)	2,000 (0)
Oklahoma	6,800 (22)	156 (78)	-	-
Oregon	486 (80)	284 (78)	152 (78)	158 (78)
South Dakota	1,800 (20)[1]		2,500 (1.5)	-
Texas	5,418 (70)	882 (97)	-	25 (100)
Utah	155 (100)[1]		22 (100)	125 (75)
Washington	1,000 (52)	300 (25)	970 (0.5)	490 (1)
Wyoming	207 (83)	14 (36)	18 (18)	148 (25)
Total	30,963 (51)	3,461 (75)	12,276 (11)	5,745 (37)

[1]Dryland and irrigated wheat not separated in estimates.

[2]Infested acreage not estimated.

Table 2. Estimated number of acres treated and cost of Russian wheat aphid control in the western United States, 1989.

	Acres treated (x 1,000)[1]									
	Winter wheat									
	Dryland		Irrigated		Spring wheat		Barley		Treatment cost/acre (aerial)	Total cost of treatments (x $1,000)
	1x	2x	1x	2x	1x	2x	1x	2x		
Arizona	-	-	2	1	-	-	0.6	0.2	9.50	48
California	0	2	10	0	-	-	-	-	20.00	280
Colorado	832	104[2]	-	-	3.5	0.5	64	8[2]	8.30	9,545
Idaho	55	-	55	-	35	-	75	-	13.00	2,860
Kansas	135	0	0	0	-	-	0	0	7.68	1,037
Montana	5	0	0	0	2	0	0	0	8.00	56
Nebraska	7	0	0	0	-	-	1	-	8.00	64
New Mexico	30	0	50	0	-	-	1	-	7.55	612
Nevada	-	-	60	0	0	0	0	0	-	-
Oregon	53.6	8.6	29	11	10	30	34.3	7.4	8.50	1.954
Texas	61	0	164	5	-	-	2	0	7.41	1.756
Utah	8	0	-	-	0	0	0	0	8.50	68
Washington	300	0	0	0	0.1	0	1.2	0	8.54	41
Wyoming	3.5	0	0	0	0.1	0	1.2	0	8.54	41
Total	1,490	115	310	17	55	30	183	16		20,939

[1] North Dakota and South Dakota report no treatments for the Russian wheat aphid. Oklahoma reported an insignificant amount of treatment because of drought and freeze problems.

[2] In addition Colorado reported 7,500 acres of winter wheat and 1,000 acres of barley treated three times.

Table 3. Estimated yield reductions attributed to Russian wheat aphid in the western United States, 1989.

	Estimated yield losses ($1,000)[1]					
	Winter wheat					
	Dryland	Irrigated	Spring wheat	Barley	Total	Remarks
Arizona	0	852	-	128	980	$2.74/bu barley.
California	260	3,900	-	-	4,160	Estimated losses in infested area 0.1 T/A (dryland) and 0.1 T/A (irrigated).
Colorado	10,696	-	92	1,465	12,253	Calculated using 5% yield reduction (winter wheat, barley) or 0.5% (spring wheat). $3.74/bu
Idaho	6,373	4,406	4,331	7,820	22,930	$3.50/bu wheat; $2.45/bu barley.
Kansas	224	0	-	0	224	17% yield loss for 15,000 acres infested and not treated.
Montana	1	0	0.5	0	1.5	Calculated using approx. 0.1% yield reduction.
Nebraska	829	0	-	39	868	Calculated using 1% yield reduction for wheat (743,000 A) and 5% for barley. $2.10/bu
New Mexico	-[2]	1,805	-	0	1,805	$3.80/bu wheat.
Nevada	-	3.9	0	0	3.9	Calculated using 0.5% yield reduction.
Oklahoma[2]	-	-	-	-	-	-
Oregon	546	791	943	631	2,911	Calculated using 1% (winter wheat) and 3% (spring wheat and barley) yield reduction. $4.14/bu wheat; $2.25/bu barley.
Texas	12,984	4,752	-	146	17,882	$3.82/bu wheat; $2.33/bu barley.
Utah[1]						
Washington	5,925	0	46	32	6,003	$4.30/bu wheat; $2.20 bu barley.
Wyoming	900	52	17	209	1,178	$4.20/wheat; $4.06 bu barley. Calculated using 2% yield reduction for barley.
Total	38,738	16,562	5,430	10,470	71,200	

[1] Yield reductions calculated at 5% of yield in infested acres and using $3.90/bu wheat price unless stated otherwise in remarks.

[2] Not estimated due to drought (New Mexico, Oklahoma) and freeze problems (Oklahoma).

Table 4. Economic impact of the Russian wheat aphid on small grains production in the western U.S., 1987-89.

	1987[1]	1988[2]	1989
Infested acres (x 1,000)	16,481.0	27,971.7	19,574
Control costs ($1,000)	$ 17,217.5	$ 17,096.8	$ 20,939
Losses from yield reductions ($1,000)	$ 36,652.0	$ 113,254.5	$ 71,200
Total losses ($1,000)	$ 53,869.5	$ 130,351.3	$ 92,139

[1] Morrison et al. 1988.

[2] Peairs et al. 1989.

Committee Member Resources

PUBLICATIONS

Ali, A. A., A. S. Rajab and H. Al-Hussiani. 1985. Relative susceptibility of different wheat varieties to aphid infestation: J. Ag Water Resources. Res. (Iraq) 4:25-40.

Bechinski, E. J. 1990. Bioeconomics, economic injury levels and the Russian wheat aphid. Aphid-plant interactions symposium, Stillwater, OK. Abstract TH8.

Bechinski, E. J. 1990. Russian wheat aphid: Make the right decision this fall with sequential sampling. Idaho Farmer-Stockman. 107(9):32-33.

Behle, R. W., and G. J. Michels. 1989. Pilot beneficial insect (*Coccinellid*) release for control of Russian wheat aphid in the Texas Panhandle. Tex. Ag Exp. Sta. Progress Rept. PR-4650.

Behle, R. W., and G. J. Michels. 1990. Russian wheat aphid development, reproduction and survival on wheat and rye grown in four host-plant media. Southwest. Entomol. 15:109-121.

Bernal, J., D. Gonzalez, E. Natwock, R. Leon-Lopez, P. Marsh, M. Schauff and J. Johnson. (In press). Preliminary assessment of resident arthropod parasites and predators of Russian wheat aphid in some areas of California. Calif. Ag.

Burton, R. L., D. R. Porter and J. A. Webster. 1990. Russian wheat aphid resistant barleys. *In* American barley research workshop minutes. Attachment 1, May 14, 1990, Sacramento, CA.

Bush, L., J. E. Slosser and W. D. Worrall. 1989. Variations in damage to wheat caused by Russian wheat aphid (Homoptera:Aphididae) in Texas. J. Econ. Entomol. 82:466-471.

Cooksey, D., G. Johnson, G. Jensen and W. Lanier. 1990. Montana crop health report. (Bi-weekly Newsletter, Montana State University.)

Cuperus, G., S. Coppock, W. Morrison, D. McBride and F. Peairs. 1989. Insect management. pp. 21-8. *In* Stuckey, R., J. Nelson, G. Cuperus, E. Oelke and H. Bahn. 1989. Wheat pest management: A guide to profitable and environmentally sound production, pesticide safety and use. Oklahoma State University/Cooperative Extension Service/Wheat Industry Resource Committee. 68 pp.

Danielson, S. D., R. J. Wright, J. F. Witkowski, G. L. Hein, J. B. Campbell, L. L. Peters, A. F. Hagen, F. P. Baxendale, K. J. Janis, R. C. Seymour and J. A. Kalisch. 1990. 1990 insect management guide for alfalfa, soybeans, wheat, range and pasture.

du Toit, F. 1987. Resistance in wheat (*Triticum aestivum*) to *Diuraphis noxia* (Hemiptera:Aphididae). Cer. Res. Comm. 15:175-179.

du Toit, F. 1988. Another source of Russian wheat aphid (*Diuraphis noxia*) resistance in *Triticum aestivum*. Cer. Res. Comm. 16:105-106.

du Toit, F. 1989. Components of resistance in three bread wheat lines to *Diuraphis noxia* (Homoptera:Aphididae) in South Africa. J. Econ. Entomol. 82: (In press).

Feng, M. G., and R. M. Nowierski. Spatial distribution and sampling plans for four species of cereal aphids (Homoptera: Aphididae) infesting spring wheat in Southwestern Idaho. J. Econ. Entomol. (Submitted).

Feng, M. G., and R. M. Nowierski. 1990. Spatial patterns and sampling plans for cereal aphids (Homoptera: Aphididae) killed by entomophthoralean fungi and hymenopterous parasitoids in spring wheat. Entomophaga. (Submitted).

Feng, M. G., R. M. Nowierski, A. L. Sharen and D. C. Sands. Entomophthoralean fungi infecting cereal aphids in Montana. Pan. Pac. Entomol. (Submitted).

Gilstrap, F. E. 1989. Russian wheat aphid, biological control and IPM in the Midwest. (Abstract). North Central Branch of the Entomological Society of America. p 133.

Gilstrap, F. E., and L. K. McKinnon. 1988. Response of native parasites to Russian wheat aphid. Tex. Ag Exp. Sta. Prog. Rept. PR-4558. 5 pp.

Gilstrap, F. E., and L. K. McKinnon. 1989. Biological control of Russian wheat aphid at State Agricultural Experiment Stations. Proc. Second Russian Wheat Aphid Workshop, Oct. 11-12, 1988. Denver, CO. pp. 31-2.

Gilstrap, F. E., L. K. McKinnon, D. Gonzalez, J. B. Woolley and R. A. Wharton. 1989. The 1988 importations and shipments of parasites for biological control of Russian wheat aphid. TAEX PR-4674.

Gonzalez, D., F. E. Gilstrap, P. Stary and L. McKinnon. 1989. Foreign exploration for Russian wheat aphid natural enemies: A summary of cooperative efforts by State University Agricultural Experiment Stations, USDA/APHIS, USDA/ARS, CIBC, SRC, ICARDA and ITGC. Proc. Third Russian Wheat Aphid Workshop, Oct. 25-27, 1989. Albuquerque, NM. pp. 113-128.

Gray, M. E., G. L. Hein, D. D. Walgenbach and N. C. Elliott. 1990. The impact of Russian wheat aphid, *Diuraphis noxia* (Homoptera: Aphididae), on winter wheat and spring wheat infested during different plant growth stages under greenhouse conditions. J. Econ. Entomol. (in press)

Halbert, S. E. 1987. Russian wheat aphid in Idaho. Idaho Grain. August/September, pp. 8-9.

Halbert, S. E., and R. L. Johnston. 1988. The Russians are here. Idaho Farmer-Stockman. April, pp. 28-29.

Halbert, S. E., and T. M. Mowry. 1990. The Idaho aphid suction trap survey system. Idaho Grain. March/April, p. 10.

Halbert, S. E., L. E. Sandvol and G. W. Bishop. 1990. Aphids infesting Idaho small grains and corn. University of Idaho CIS 816.

Halbert, S. E., J. Connelly and L. E. Sandvol. Suction trapping of aphids in western North America (Emphasis on Idaho). Acta Phytopathalogica Hungarica. (In press).

Halbert, S. E., L. E. Sandvol, R. L. Stoltz and H. W. Homan. 1990. Russian wheat aphid. University of Idaho CIS 817.

Halbert, S. E., T. M. Mowry, B. J. Connelly, L. E. Sandvol, G. W. Bishop and R. L. Stoltz. 1985-90. The Idaho aphid flier. (Weekly newsletter, University of Idaho.)

Halbert, S. E., T. M. Mowry, L. E. Sandvol and R. L. Stoltz. 1990. Russian wheat aphid update. Proceedings of the University of Idaho Winter Commodity Schools. 22:30-36.

Hammon, R. W., F. M. Judson and F. B. Peairs. 1989. Influence of furrow direction on overwintering Russian wheat aphid distribution in the Grand Valley of Colorado. pp. 152-154. *In* Proceedings 3rd Russian Wheat Aphid Conference, Albuquerque, NM, Oct. 25-27, 1989.

Hammon, R., S. Armstrong, W. Meyer, C. Walker and F. Peairs. 1989. Alternate hosts of the Russian wheat aphid in Colorado. pp. 4-7, *In* Proceedings 3rd Russian Wheat Aphid Conference, Albuquerque, NM, Oct. 25-27, 1989.

Harvey, T. L., and T. J. Martin. 1990. Resistance to Russian wheat aphid, *Diuraphis noxia*, in wheat (*Triticum aestivum*). Cer. Res. Comm. 18: (In press).

Hein, G. L. 1989. Russian wheat aphids: Windshield survey not enough. Nebraska Farmer. September 2, p. 84.

Hein, G. L., F. P. Baxendale, J. B. Campbell, A. F. Hagen and J. A. Kalisch. Russian wheat aphid. Extension publication 689-936. Coop. Ext. Service, University of Nebraska.

Hein, G., L. Brooks, G. Johnson, W. Massey, D. McBride, P. Morrison, J. Schultz, E. Spackman and F. Peairs. 1990. Economic impact of the Russian wheat aphid in the western United States: 1988-89. Great Plains Agricultural Council Pub. (In press).

Johnson, G. D. 1989. The Russian wheat aphid: Identification, biology and management. Montana State University. EB49.

Johnson, G. D., K. Kammerzell and S. Hudson. 1989. Control of Russian wheat aphid, 1989. Insect. & Acar. Tests. 14:303-304.

Kirijak, I., F. Gruber, T. Poprawski, S. Halbert and L. Elberson. Occurrence of sexual morphs of Russian wheat aphid, *Diuraphis noxia* (Homoptera:Aphididae), in several locations in the Soviet Union and the northwestern United States. Proceedings of the Entomological Society of Washington 92:672-674.

Legg, D., and T. Christiansen. 1989-90. Russian Wheat Aphid News. No. 1-27. June 1989 - August 1990.

McKinnon, L. K., and F. E. Gilstrap. 1989. Biological control of Russian wheat aphid: Parasites imported in 1988. (Abstract) Internat. Symp. on Biological Control Implementation. p. 185.

Meyer, W., and F. Peairs. 1989. Observations on biological control agents in Colorado. pp. 96-98, *In* Proceedings 3rd Russian Wheat Aphid Conference, Albuquerque, NM, Oct. 25-27, 1989.

Meyer, W. L., K. K. Nkongolo, F. B. Pearis and J. S. Quick. 1989. Mechanism of resistance of a wheat cultivar to Russian wheat aphid. pp. 23-24. *In* Proceedings 3rd Russian Wheat Aphid Conference. Albuquerque, NM, Oct. 25-27, 1989.

Meyer, W., S. Armstrong, R. Hammon, M. Lordier, C. Walker and F. Peairs. 1989. Suction trap survey in Colorado: 1988 vs. 1989. pp. 37-40. *In* Proceedings 3rd Russian Wheat Aphid Conference. Albuquerque, NM, Oct. 25-27, 1989.

Michels, G. J., and R. W. Behle. 1988. Reproduction and development of *Diuraphis noxia* (Homoptera:Aphididae) at constant temperatures. J. Econ. Entomol. 81:1097-1101.

Michels, G. J., and R. W. Behle. 1989. Influence of temperature on reproduction, development and intrinsic rate of increase of Russian wheat aphid, greenbug and bird cherry-oat aphid (Homoptera:Aphididae). J. Econ. Entomol. 82:439-444.

Morrison, W., F. Baxendale, L. Brooks, C. Burkhardt, J. Campbell, G. Johnson, W. Massey, D. McBride, F. Peairs and J. Schultz. 1988. The Russian wheat aphid: A serious new pest of small grains in the Great Plains. Great Plains Agricultural Council Pub. 124, 5 pp.

Nknogolo, K. K., J. S. Quick, F. B. Peairs and W. L. Meyer. 1990. Gene location for Russian wheat aphid resistance of "Imperial" rye using wheat-rye addition lines. Cereal Res. Commun. (In press).

Nkongolo, K. K., J. S. Quick, A. E. Limin, D. B. Fowler, F. B. Peairs and W. L. Meyer. 1990. Russian wheat aphid (*Diuraphis noxia*) resistance in wheat, wheat relatives and interspecific hybrids. Can. J. of Plant Sci. (In press).

Nkongolo, K. K., J. S. Quick, Q. L. Meyer and F. B. Peairs. 1989. Resistance of wheat and related species to the Russian wheat aphid (RWA), *Diuraphis noxia* in greenhouse screening tests. Agronomy Abstr., American Society of Agronomy, Madison, WI:94

Nkongolo, K. K., J. S. Quick, W. L. Meyer and F. B. Peairs. 1989. Russian wheat aphid resistance of wheat, rye and triticale in greenhouse tests. Cereal Res. Commun. 17:227-232.

Nkongolo, K. K., J. S. Quick, W. L. Meyer and F. B. Peairs. 1990. Effect of vernalization on Russian wheat aphid resistance of wheat and triticale in greenhouse screening tests. Cereal Res. Commun. (In press).

Nowierski, R. M., A. L. Scharen and D. C. Sands. Age-specific life-table analysis of the Russian wheat aphid grown on barley in benzimidazole agar. Environ. Entomol. (Submitted).

Peairs, F. B. 1989. Aphids in small grain. Colorado State University Service in Action, 5.568 (revised), 4 pp.

Peairs, F. B., and G. O'Malia. 1990. Russian wheat aphid. Colorado State University Cooperative Extension video. Trt. 18:30.

Peairs, F. B., and S. D. Pilcher. 1989. 1989 Colorado field crop insect management research and demonstration trials. Colorado State Univ. Ag Exp. Sta. Tech. Bull. LTB89-6, 34 pp.

Peairs, F. B., L. Brooks, G. Hein, G. Johnson, W. Massey, D. McBride, P. Morrison, J. Schultz, E. Spackman and F. Peairs. 1989. Economic impact of the Russian wheat aphid western United States: 1987-88. Great Plains Agric Council Pub. 129, 11 pp.

Peairs, F., L. Brooks, G. Hein, G. Johnson, W. Massey, D. Mc W. Morrison, J. Schultz and E. Spackman. 1989. The R wheat aphid: A serious new pest of small grains in the w United States. Great Plains Agricultural Council Pub. 12

Pike, K. S. and L. K. Tanigoshi. 1989. Jordan exploration: R wheat aphid and its natural enemies. pp. 140-43. *In* R wheat aphid, Proceedings 3rd Russian Wheat Conference, Albuquerque, NM, Oct. 25-27, 1989.

Pike, K. S., D. Allison, L. Boydston, C. O. Qualset, H. E. Vogt a G. Summers. 1989. Suction trap reveals more than 60 a including Russian wheat aphid, a new pest in California. Ag 43(6):22-24.

Pike, K. S., D. Allison, L. K. Tanigoshi, R. F. Harwood, S. L. Cle S. E. Halbert, C. M. Smith, J. B. Johnson, G. L. Reed and Zwer. 1990. Biology, damage, and management of R wheat aphid. Pacific Northwest Research Bulletin. 24 p press).

Quick, J. S. 1989. Results of the first uniform Russian wheat seeding test, p. 14. In Russian wheat aphid. Proceedin Russian Wheat Aphid Conference, Albuquerque, NM, O 27, 1989.

Quick, J. S., K. K. Nkongolo, F. B. Peairs and W. L. Meyer. Breeding for Russian wheat aphid resistance. Proceedir Russian Wheat Aphid Conference, Albuquerque, NM, C 25-27, 1989.

Quick, J. S., K. K. Nkongolo, W. L. Meyer and F. B. Peairs Breeding for Russian wheat aphid resistance at Colorac Univ. Proc. of the Eighteenth Hard Red Winter Wheat Conference. Dallas, Texas, January 30 - February 2.

Quick, J. S., K. K. Nkongolo, W. L. Meyer, F. B. Peairs and B. 1989. Breeding for Russian wheat aphid resistance, p *In* Russian wheat aphid, Proceedings 3rd Russian Whea Conference, Albuquerque, NM, Oct. 25-27, 1989.

Quick, J. S., K. K. Nkongolo, W. L. Meyer, F. B. Peairs and B. 1990. A wheat, P1372129, resistant to the Russian wheat Crop Sci. (Accepted).

Remington, T., F. Peairs, S. Pilcher, W. Meyer, J. Rudolph a Johnsen. 1989. Nontarget effects of aerially-applied R wheat aphid insecticides in Colorado. pp. 67-70. *In* Proce 3rd Russian Wheat Aphid Conference, Albuquerque, October 25-27, 1989.

Sandvol, L. E., G. A. Lee and C. M. Smith. 1989. The here...Russian wheat aphids in Idaho. Idaho Grain Gro May, 1989. pp 8-10.

Smith, C. M., D. J. Schotzko, R. S. Zemetra and E. J. So Categories of resistance in wheat, *Triticum aestivum* to Russian wheat aphid (Homoptera:Aphididae). J. Ec Entomol. (Submitted).

Smith, C. M., D. Schotzko, R. S. Zemetra, E. J. Souza and Schroeder-Teeter. 1990. Identification of Russian wheat ap (Homoptera:Aphididae) resistance in wheat, *Triticum aestivu* L. J. Econ. Entomol. 83: (In press).

Summers, C. G. *Siphunculus*. Newsletter published 10-15 tim yearly. (Contains counts of major economic aphid species fro the suction traps.)

Summers, C. G., A. S. Newton, M. Kirk and S. R. Temple. (In pres Transmission of beet yellows and beet mosaic viruses noncolonizing aphid vectors. J. Econ. Ent.

University of California. 1988. Russian wheat aphid -- How recognize this new pest and its damage.

University of California. *Cooperative Extension County Farm Advi Newsletters*. Containing information of RWA management.

University of California. *Cooperative Extension Small Gra Specialist*. Four newsletters yearly published on topics rela to small grain production. (Most issues contain information RWA.)

Webster, J. A., C. A. Baker and R. L. Burton. 1989. Progress in locating Russian wheat aphid resistance in wheat and barley, pp. 18-19. *In* Russian wheat aphid, Proceedings 3rd Russian Wheat Aphid Conference, Albuquerque, NM, Oct. 25-27, 1989.

Webster, J. A., K. J. Starks and R. L. Burton. 1987. Plant resistance studies with *Diuraphis noxia* (Homoptera: Aphididae), a new United States wheat pest. J. Econ. Entomol. 80:944-949.

Webster. 1990. Resistance in triticale to the Russian wheat aphid (Homoptera:Aphididae). J. Econ. Entomol. 83:1091-1095.

Zemetra, R. S., D. Schotzko, C. M. Smith and E. J. Souza. 1990. Seedling resistance to the Russian wheat aphid in white wheat germplasm. Cer. Res. Comm. (In press).

WORKSHOPS AND PRESENTATIONS

Gonzalez, D. 1990. Biological control of Russian wheat aphid. Santa Barbara County Cooperative Extension Wheat Meeting. May 2, 1990. Santa Ynez, CA.

Gonzalez, D. 1990. Biological control of the Russian wheat aphid. San Joaquin County Wheat Growers Meeting. February 27, 1990. Stockton, CA.

Halbert, S. E. Barley yellow dwarf virus - RWA relationship. PNW Tri-State Cooperative RWA & E Update. Pendleton, OR. April 1990.

Halbert, S. E. Cereal aphids and their control. Plant Pathology and Entomology Short Course. Ontario, OR. February 1990.

Halbert, S. E. Exploration in the Soviet Union for natural enemies of Russian wheat aphid. Presentation for Parma, ID Lions Club. April 1990.

Halbert, S. E. Exploration in the Soviet Union for natural enemies of the Russian wheat aphid. Presentation in Caldwell, ID. March 1990.

Halbert, S. E. Russian wheat aphid update: Cereal schools in Payette, Caldwell and Emmett, ID. February 1989.

Halbert, S. E. Status of RWA in the PNW. Oregon State IPM School, Pendleton, OR. February 1989.

Halbert. S. E. Russian wheat aphid economic thresholds. Cereal schools in Idaho Falls and Pocatello, ID. February 1990.

Hein, G. L. Russian wheat aphid informational meeting. May 10, 1990. Kimball, NE.

Hein. G. L. Russian wheat aphid informational meeting. May 18, 1990. Chadron, NE.

Johnson, G. D. Chemical company plot tours. Bozeman, Great Falls, MT. July, 1990.

Johnson, G. D. Russian wheat aphid field tours. Great Falls, Geraldine, Ryegate, Ft. Benton and Big Sandy, MT. May 1990.

Johnson, G. D. Russian wheat aphid research station tours. Moccasin and Huntley, MT. July 1990.

Johnson, G. D. Russian wheat aphid update. 7 meetings, Broadus, Ekalaka, Baker, Terry, Jordan, Miles City, and Forsyth, MT. April 1990.

Johnson, G. D. Russian wheat aphid update. AgriBasics, Great Falls, MT. January 1990.

Johnson, G. D. Russian wheat aphid update. Fairfield Ag Days, Fairfield, MT. February 1990.

Johnson, G. D. Russian wheat aphid. MABA/MgEA, Great Falls, MT. January 1990.

Johnson, G. D. Russian wheat aphid: Survey and Sights. Hill County Ag Producers, MT. February 1990.

Johnson, G. D. Russian wheat aphid: Identification, biology and control. Montana State University IPM School, Bozeman, March 1990.

Legg, D. Russian wheat aphid. Sampling workshop. April 24, 1990, held near Lingle, WY.

Legg, D. Russian wheat aphid. Sampling Workshop. April 24, 1990, held near Slater, WY.

Qualset, C. O. 1990. Development of host plant resistance to Russian wheat aphid. Santa Barbara County Cooperative Extension Wheat Meeting. May 2, 1990. Santa Ynez, CA.

Summers, C. G. 1989. Biology and Control of the Russian wheat aphid. Merced/Madera Cooperative Extension Wheat Meeting. Oct. 24, 1989. Chowchilla, CA.

Summers, C. G. 1989. Biology and Control of the Russian wheat aphid. Glenn County Cooperative Extension Wheat Meeting. Nov. 16, 1989. Ord, CA.

Summers, C. G. 1989. Biology and control of the Russian wheat aphid. Northern California CACPA Annual Meeting. Nov. 15, 1989. Chico, CA.

Summers, C. G. 1989. Biology and control of the Russian wheat aphid. Santa Barbara Cooperative Extension Wheat/Alfalfa Meeting. Oct. 25, 1989. Santa Ynez, CA.

Summers, C. G. 1989. Biology and ecology of the Russian wheat aphid. Kings County Cooperative Extension Wheat Meeting. Sept. 21, 1989. Laton, CA.

Summers, C. G. 1989. Biology and ecology of the Russian wheat aphid in California. Small Grains Workshop. October 11, 1989. Davis, CA.

Summers, C. G. 1989. Status of Russian wheat aphid in California. Meeting of California Wheat Commission. Aug. 10, 1989. Sacramento, CA.

Summers, C. G. 1989. Status of the Russian wheat aphid in California. Annual Meeting of California Seed Growers Association. Sept. 20, 1989. Sacramento, CA.

Summers, C. G. 1990. Biology and control of Russian wheat aphid. San Joaquin County Wheat Growers Meeting. Feb. 27, 1990. Stockton, CA.

Summers, C. G. 1990. Biology and control of Russian wheat aphid. Tulare County Cooperative Extension Wheat Meeting. Jan. 11, 1990. Tulare, CA.

Summers, C. G. 1990. Biology and ecology of Russian wheat aphid. Northern California Entomology Society. May 4, 1990. Sacramento, CA.

Summers, C. G. 1990. Biology of Russian wheat aphid. Santa Barbara County Cooperative Extension Wheat Meeting. May 2, 1990. Santa Ynez, CA.

Summers, C. G. 1990. Research status of host plant resistance to Russian wheat aphid. University of California Small Grains Field Day. May 18, 1990. Davis, CA.

Summers, C. G. 1990. Russian wheat aphid research in California. University of California Plant Protection Seminar. June 2, 1990. Parlier, CA.

Summers, C. G. 1990. Status of Russian wheat aphid host plant resistance studies. California Wheat Commission. April 4, 1990. Woodland, CA.

National Russian Wheat Aphid Steering Committee (NRWA-SC) Members

Sponsored by:
National Association of State Departments of Agriculture

Dr. Henry Bahn
National Program Leader
Grain Marketing
USDA, Extension Service
Room 3337, South Building
Washington, DC 20250-0900
202-447-4387
USDA, Extension System

Dr. Ralph Gantz
4009 94th Street
Lubbock, TX 79423
806-798-2432
National Agricultural Chemical Association (NACA)

Mr. Tom Iverson
Idaho Barley Commission
HCR 61, Box 129
Bonners Ferry, ID 83805
208-267-2282
National Barley Growers Association

Dr. Gary Lee, Chairman
Agricultural Experiment Station
College of Agriculture
University of Idaho
Moscow, ID 83843
208-885-7173
Western Regional Coordinating Committee-66 (WRCC-66)

Dr. W. Metterhouse
New Jersey Department of Agriculture
Division of Plant Industry
John Fitch Plaza, CN-330
Trenton, NJ 08625
609-292-5441
National Plant Board (NPB)

Dr. Dale Meyerdirk, Secretary
6505 Belcrest Road
Room 814, Federal Building
Hyattsville, MD 20782
301-436-5667
USDA, Animal and Plant Health Inspection Service (APHIS)

Dr. Robert Riley & Dr. Jim Cate
USDA, CSRS, PAS
Room 305-A
Washington, DC 20251
202-401-6301
USDA, Cooperating State Research Service (CSRS)

Dr. Richard Soper
USDA, ARS, NPS
Building 005, Barc West
Beltsville, MD 20705
301-344-3930
USDA, Agricultural Research Service (ARS)

Mr. Robert Sullivan
Plant Industries
700 Kipling
Lakewood, CO 80215
303-239-4140
National Association of State Departments of Agriculture (NASDA)

Mr. William Warren
Colorado Association of Wheat Growers
2340 WCR #55
Keenesburg, CO 80643
303-732-4505
National Association of Wheat Growers (NAWG)